د/شريف

Lec [7]

Heat transfer

chapter [4]

22/4/2015

Natural Convection → الحمل الحر

$$q = hA\Delta T \begin{cases} \Delta T = t_s - T_\infty \\ \Delta T = T_\infty - t_s \end{cases}$$ (الأكبر - الأصغر)

$Nu = f[Ra]$

- Nu : Nusselt No.
- Ra : Ralyigh No.
- Gr : Grashoff No.
- Pr : Prandtel No.

} بدون وحدات قياس

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- $Nu = \dfrac{h L_c}{K}$
- $Ra = G_r \cdot P_r$
- $Gr = \dfrac{g \beta \Delta T L_c^3}{\nu^2}$
- $Pr = \dfrac{\mu \cdot C_p}{K} = \dfrac{\rho \nu C_p}{K}$

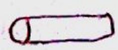
where:
- μ : Dynamic viscosity [Kg/m.s]
- ρ : Density [Kg/m³]
- C_p : specific capactance [W/kg.K]
- h : Convection heat transfer coefficient [W/m²K]
- L_c : characteristic Length [m]
- k : thermal conductivity [W/mK]
- g : Acceleration Gravity [m/s²]
- ν : Kinematic Viscosity [m²/s]

$$\boxed{\beta = \frac{1}{T_{mean}}} [K^{-1}] \Rightarrow T_{mean} = \left(\frac{t_s + T_\infty}{2}\right) + 273 \ [°K]$$

* How to calculate characteristic length [Lc] ??

كيفية حساب (Lc)

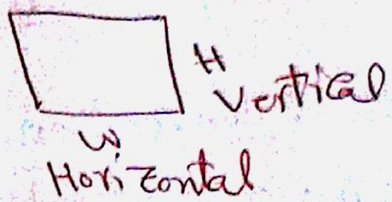
[1] Sphere : $\therefore \boxed{L_c = D}$

[2] Cylinder (Pipe, tube) ⇒
- → Vertical  $\therefore \boxed{L_c = H}$
- → horizontal  $\boxed{L_c = D}$

[3] Plate (plane wall)

[1] flow Parallel Vertical surface

$\therefore \boxed{L_c = H}$



[2] flow Parallel Horizontal Surface

$\therefore \boxed{L_c = W}$

[II] - Sheet [4]

[1] Properties of Air

$P_r = 0.7$

$\nu = 18.41 \times 10^{-6}$ m²/s

$K = 28.15 \times 10^{-3}$ W/mK

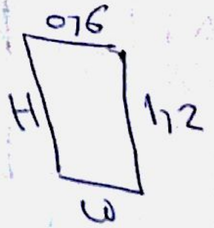
Correlation is given by:

$Nu = 0.13 [Ra]^{1/3}$

Given: $W = 0.6$ m, $H = 1.2$ m

vertical Plate $\Rightarrow L_c = H = 1.2$ m

$t_s = 90°C$, $T_{air} = 14°C$



Solution:

- $Nu = 0.13 [Ra]^{1/3}$
- $T_m = \left[\frac{t_s + T_{air}}{2}\right] + 273 = \square$ °K
- $\beta = \frac{1}{T_m} = \square\ K^{-1}$

$Ra = Gr \cdot Pr$

$$Gr = \frac{g \beta [t_s - T_{air}] H^3}{\nu^2} = \square$$

$$[Ra]^{1/3} = [Gr \cdot Pr]^{1/3} = \square$$

$$Nu = 0.13 [Ra]^{1/3} = \boxed{\ }$$

$$Nu = \frac{hH}{k} = \boxed{\ } \Rightarrow h = \square \text{ W/m}^2\text{K}$$

$$q = hA[t_s - T_{air}] = \square, \quad A = [W \times H]$$

$\boxed{25}$- sheet[4]

Properties of fluid

$\rho = 10^4 \ Kg/m^3$

$\mu = 0.866 * 10^{-3} \ kg/m.s$

$C_p = 150.7 \ w/kg.k$

$K = 13.02 \ w/mk$

Correlation:

$Nu = 0.13[Gr.Pr]^{1/3}$

Given:

$H = 2.2m$

$W = 1.4 \ m$

Vertical plate

$\Rightarrow \boxed{L_c = H} = 2.2m$

both sides

$\hookrightarrow q = 2hA[t_s - T_f]$

$\mu = \rho \nu$

$P_r = \frac{\mu c_p}{k} = \frac{\rho \nu c_p}{k}$

Solution: $T_m = \left[\frac{t_s + T_f}{2}\right] + 273 = \square \ k$

$\beta = \frac{1}{T_m} = \square \ k^{-1}$

$Gr = \frac{g\beta[t_s - T_f]H^3}{\nu^2} = \frac{g\beta(t_s - T_f]H^3 \rho^2}{\mu^2} = \square$

$Pr = \frac{\mu c_p}{K} = \square$

$Nu = 0.13[Gr.Pr]^{\frac{1}{3}} = \square = \frac{hH}{k} \Rightarrow h = \square \ w/m^2k$

6- sheet[4]:

Properties of Air

$\rho = 1.025 \ kg/m^3$

$C_p = 960 \ w/kg \ K$

$\nu = 15.06 \times 10^{-6} \ \frac{m^2}{s}$

$K = 0.025$

Correlation: $Nu = 0.12[Gr.Pr]^{1/3}$

Given:

cylinder : $D = 0.3m$

Vertical $L_c = H = 1.6m$

$A = 2\pi r L$

$h = ?$

Solution: $T_m \left(\frac{t_s + T_{air}}{2}\right) + 273 = \square \ °K$

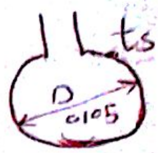
$\beta = \frac{1}{T_m} = \square \ k^{-1}$

$Gr = \frac{g\beta[t_s - T_{air}]H^3}{\nu^2} = \square$

$Pr = \frac{\rho \nu c_p}{K} = \square$

$Nu \Rightarrow \frac{hH}{K} = \square \Rightarrow h = \square \ w/m^2k \ , \ q = hA[t_s - T_{air}]$

$\boxed{8}$ -Sheet $\boxed{4}$



$t_s = 115\,°C$

Air

$T_{air} = 25°c$

$h = ?$

Properties of Air

$Pr = 0{,}694$, $K = 2{,}964 * 10^{-2}$ W/mK

$\nu = 20{,}02 * 10^{-6}$ m²/s

Correlation :

$Nu = 0{,}6\,[Ra]^{\frac{1}{4}}$

$\boxed{L_c = D}$

Sphere $A = 4\pi r^2$

Power = 60 W

$q_{conv} = hA\,(t_s - T_{air})$

$\boxed{\% = [q_{conv}/Power] * 100 = \square}$ (النسبة المفقودة من ال Power)

$T_m = \left[\frac{t_s + T_{air}}{2}\right] + 273 = \square\,°K$

$\beta = \frac{1}{T_m} = \square\,K^{-1}$

$Gr = \frac{g\beta\Delta T D^3}{\nu^2}$

$Pr = \frac{\rho\nu c_p}{K}$

$Nu = \boxed{\,} \Rightarrow \frac{hD}{K} \Rightarrow h = \square$ w/m²k

$q_{conv} = hA\,[t_s - T_a] = \square$

$\% = [q/Power] * 100 = 6{,}87\,\% \rightarrow$ نسبة الفقد في الطاقة (Power)